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HOTLINE! 56

Optimizing ASC Tube Traps

We're pleased to see the worldwide acceptance that Tube Traps have gained, in the four years since IAR's pioneering review (see Hotlines 39 & 40). Virtually all major reviewers and manufacturers use them as a key element of their listening rooms, which they rely upon for evaluating all the audio components you will buy. When reviewers publish plans of their listening rooms, most show Tube Traps in the corners.

On the other hand, we're disappointed to see that most people are realizing merely a fraction of the sonic benefits that they could obtain from Tube Traps, given all their power and flexibility. Most people apparently don't fully understand all the sonic improvements that are achievable with Tube Traps, and they don't know how to optimize the use of Tube Traps for their listening room. The purpose of this article is to help you redress this injustice to your listening room, this shortchanging of you and your enjoyment of music. It is intended as a practical, nuts and bolts guide to using and adjusting Tube Traps.

Figure 1 shows the typical Tube Trap arrangement that many people are using. The solid black rectangles represent the speakers, and the X represents the listener. The circles represent Tube Traps, with one column in each corner.

What's wrong with this typical arrangement? In the first place, it only achieves bass control, working on the room's bass resonance modes. This arrangement does absolutely nothing to exploit the power of Tube Traps in controlling wall reflections. It provides none of Tube Traps' sonic benefits in many other areas: in eliminating the dreaded mud factor (especially warmth and lower midrange regions), in reducing glare and colorations (especially midrange and upper midrange regions), in improving articulation and transparency, in improving stereo imaging and ambience, and in making the room's reverberation characteristics smooth and well behaved. These aspects are discussed below, under Perimeter Reflection Control.

Bass Control —

Furthermore, this typical arrangement is not even the optimum setup for controlling bass. A room's bass resonances occur between opposite parallel walls. Putting Tube Traps only in the corners does little to control the resonance that develops between the broad ***center*** section of opposite walls. In order to control this, you should place some bass absorbing Tube Traps at the center position of some walls. Referring to Figure 2, adding the bass Tube Trap in the center of the back wall (in back of the listener, i.e. at the bottom of the room plan as shown) is particularly crucial to controlling the front-to-back bass resonances along the presumed long dimension of the room.

Conversely, the two typical Tube Traps at the room's front corners (the speaker end, i.e. at the top of the room plan as shown) are not really that important. Why not? Because a bass resonance requires a ***pair*** of opposite walls to develop (it takes two to tango). Consequently, damping just ***one*** of the opposing walls is sufficient to control most bass resonances. You can still use Tube Traps in the front corners of the room, but they should generally be selected to be tuned to your speakers, not tuned to your room's bass resonances.

What then is the optimum setup for controlling a room's bass resonances? Figure 2 shows our suggestion. As with all our suggestions, you should regard this as a starting point, not as final gospel. Every room is different, every listener's taste and sensitivities are different, and every model speaker is different.

— Fundamental Resonance

The most important Tube Traps in Figure 2 are the three bass trap columns at the back of the room. They work to control the lowest frequency bass resonances of the room, which occur along the room's longest dimension. Note that we are presuming an oblong room, and a listening setup along the longer dimension this room's plan. If your room is close to square in plan, or (worse yet) cubic in volume, then additional control is necessary, and some of the following steps will become mandatory instead of optional. If your listening setup is across the room's longer dimension, then the bass Tube Traps should be along a side wall, with adjustments in the midrange Tube Traps along the opposite side wall in order to preserve symmetrical stereo imaging.

These three bass Tube Traps columns should be fat enough models to absorb the lowest frequency, fundamental bass resonance of the room. What is this frequency for your room? It's the half wavelength frequency for the speed of sound travelling this longest dimension. To figure this out, simply calculate 550 (which is half the speed of sound) divided by the longest dimension in feet. For example, a room with a longest dimension of 15 feet would have its fundamental resonance at 550/15 = 37 hz. To control 37 hz, you need to use the 16 inch Super Tube Trap model, which operates down to 35 hz.

The fatter the Tube Trap model, the lower in frequency its absorptive capabilities extend. The manufacturer's specs list the bass "cutoff"of the different models as follows: Super 16 inch (diameter) goes down to 35 hz; 16 inch goes down to 55 hz (as do the 16 inch half and quarter rounds); Super 11 inch goes down to 70 hz; 11 inch goes down to 85 hz (as does the 11 inch half round); and 9 inch goes down to 110 hz (as does the 9 inch half round).

Incidentally, the Super models get their extra bass extension by employing a low Q, anharmonic, eccentrically built Helmholtz resonator, which is used to shift the phase and thus increase the pressure gradient at very low frequencies, thereby improving effective absorption at these very low frequencies.

A little arithmetic shows that most people are not using fat enough Tube Traps to control the bass resonances of their listening room. If your longest room dimension is merely 11 feet (or more), then your room's fundamental bass resonance is 50 hz (or lower), and so you need to use the Super 16 inch. You shouldn't use the next cheaper model, the regular 16 inch, unless your room is less than 11 feet long.

One commonly sees rooms treated with the corners containing one 11 inch Tube Trap plus one 9 inch Tube Trap. This typical setup is only effective down to 85 hz, which would control the room's fundamental bass resonance only if the room's longest dimension were less than 6.5 feet! Thus, using the typical 11 plus 9 combination is false economy for bass control.

That's why ASC introduced the quarter round 16 inch model, as a better choice for people on a budget (see discussion below for Figure 4). The quarter round 16 incher achieves bass absorption down to 55 hz, though not as much absorption as the full round 16 inchers (it's analogous to a small speaker system, which can be engineered to put out as deep bass as a bigger system, but not as loudly). Incidentally, way back in Hotlines 39 and 40 we did recommend the 11 incher as being better for bass control than the 9 incher (which it still is), but of course at that time the 11 incher was the fattest Tube Trap available.

So far, then, we have three columns of bass Tube Traps along the back wall of the room. If this controls the room's lowest bass resonance to your satisfaction, fine. If your room still sounds too soggy in the lower bass, then you should try standing more bass Tube Trap columns along the back wall (if this doesn't help, then the sogginess is probably from the room's side to side or even its floor to ceiling resonant mode).

If you decide that you do want additional bass Tube Traps along the back wall (in addition to the three basic columns), then we suggest hanging them from the ceiling, in a horizontal orientation, along the junction of the ceiling and the back wall. This is easily accomplished with large eye screws. In Figure 2, these horizontally hung Tube Traps are shown as a rectangle filled with wavy lines. These horizontal Tube Traps should be full round models (not the economy quarter round), because, as we will discuss later, rotating them is critical for optimizing stereo imaging and ambience.

Installing Tube Traps horizontally at this junction of ceiling and back wall provides further sonic benefits. It helps control the room's bass resonant modes from the floor to ceiling dimension. And it terminates a kind of surface acoustic wave that propagates along the ceiling (which is hard surfaced in most homes), from the speaker end to the listener end of the room.

Thus, even if you find that you do not need more low bass control after installing the three bass columns along the back wall as discussed above, we would recommend that you still install this horizontal row of Tube Traps along the rear ceiling to wall junction, in order to obtain these other sonic benefits. In this case, don't use fat low bass Tube Traps, but instead use the 9 inch or 11 inch full round models (calculate the vertical mode from the floor to ceiling dimension, and select the appropriate model, depending on whether you want to absorb the fundamental of this vertical mode or let it be).

We have now dealt with the fundamental bass resonance mode along the longest room dimension, which is front to back in our example. The three tall columns and the horizontal row at the back wall also tame the room's vertical resonant mode somewhat. Now, how about the fundamental bass resonance mode that occurs between the room's side walls?

This side to side mode has also been partially tamed by the two tall columns in the corners of the back wall. But, just as we needed a third back wall column at the center of the back wall, by the same reasoning we should add bass Tube Trap columns near the center of each side wall. This is shown as the two circles midway along the side walls in Figure 2. Using the calculation discussed above, determine from the room's side to side dimension which model Tube Trap is required, to absorb the fundamental bass resonance of the room's side to side mode.

When do you stop adding low bass Tube Traps? That is, how do you know when you have achieved adequate control of low bass, of the room's fundamental resonance modes? The ideal lower bass of an audio system (which includes the listening room) should be powerfully impactive for the initial transient, but then tight and dry for the decay tail immediately thereafter (as a test, listen to a bass drum, kick drum, or plucked bass). This is the best quality lower bass transient response for your system and room (see IAR Journal 3 for discussion of bass transient response). If there's excessive lower bass resonance, the tail will sound dull and soggy (it doesn't sound boomy per se; audible boominess as such occurs from upper bass resonances).

As you add more low bass Tube Traps, the low bass should lose its dull soggy quality, and become tight and dry. As you progress, low bass ***quality*** should improve. At some point, it will sound right for your taste, given your room and speakers. If you go beyond this point by adding more low bass Tube Trap absorbers, you will start reducing the initial bass transient impact, reducing the ***quantity*** of low bass; this you probably don't want to do.

When listening for the correct point for your taste, be careful to pay attention only to the lower bass quality, that soggy vs. tight dry sound on bass transients. Ignore any upper bass boominess you might hear. There might be some upper bass boominess remaining after you have reached the optimum point of controlling lower bass. That upper bass boom relates to the harmonic overtones of the room's resonance modes (and to speaker placement); this will be dealt with by separate tactics (below).

If by chance our suggestion of three fat (low bass) Tube Trap columns along the back wall already goes beyond the op-

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timum point of absorbing low bass for your taste, then feel free to employ fewer bass Tube Traps. When we talk of a column of Tube Traps, we always mean a full height column from floor to as close to the ceiling as you can get. You could lessen the amount of low bass absorption by using half height columns. Alternatively, if your room dimensions are small enough to allow using the regular 16 incher instead of the Super 16 incher, then you could lessen the amount of absorption by using quarter round 16 inchers in the corners instead of full round 16 inchers.

Note that some listeners actually enjoy lower bass ringing resonance, from a room's fundamental modes, because it gives them added room and stomach shaking, perhaps also compensating in a crude way for their speaker's rolloff in the lower bass. Technically, a resonance in the lower bass is not correct. But this dull sogginess in bass quality doesn't bother some listeners, and they are happy to endure it, in order to get the illusion of more quantity of low bass that comes from the ringing resonance of the tail. If you are such a listener, then you might not want to control your room's fundamental bass resonance modes at all. If so, then don't take any action based on this section, and act only on the suggestions in the next section, in which we control your room's harmonic modes.

— Harmonic Modes

The second harmonics of the room's fundamental bass resonances might need further quelling, even after the fundamental has been controlled to your satisfaction (whatever degree that happens to be). There are several reasons for this. The harmonics are in the upper bass region, which is far more audible to human hearing than lower bass, thus making even a slight remaining resonant boom more objectionable. Also, most music and most loudspeakers put out far more energy in the upper bass than the lower bass, thus triggering even a slight remaining upper bass room resonance mode more frequently and more severely.

Is there a way to control upper bass boom independently of lower bass sogginess, so you can optimize each to your taste? Yes there is, thanks to the power and flexibility of Tube Traps. How? Actually, there are two basic strategies, which you can combine, to yield a variety of specific tactics.

If you want to control upper bass boom without further affecting low bass, one strategy is to select skinnier Tube Trap models, which have a higher frequency bass cutoff. They would control the second harmonic modes of the room, without affecting the fundamental modes. To select the appropriate Tube Trap model for controlling only the second harmonic mode (and higher order modes) of a particular room dimension, pick the model whose cutoff frequency is lower than the second harmonic frequency, but higher than the fundamental frequency. The second harmonic frequency is simply twice the fundamental frequency (or you can simply change the above calculation formula to 1100 divided by the appropriate room dimension in feet).

This strategy of selecting skinnier Tube Traps, to affect only the upper bass, is only partially effective. The bass rolloff of a Tube Trap's absorption capability is gradual, rather than a sudden cutoff. Thus, Tube Traps selected for an upper bass cutoff would still absorb some lower bass. (Note, incidentally, that you can use this fact to advantage if you are on a budget; if you want to absorb say 50 hz, you can cheat a bit by using a Tube Trap rated at a 55 hz cutoff, instead of having to spend more for the Tube Trap with the 35 hz cutoff.) Also, the second harmonic of the longest dimension room resonance mode might be very close in frequency to the fundamental of a shorter dimension room mode, so a Tube Trap selected to absorb the upper bass second harmonic of one mode might also absorb the upper bass fundamental of another dimension's mode (although this might be desirable, given that both are contributing to the undesirable upper bass boom you hear and want to control).

The second strategy overcomes these shortcomings, and allows you to precisely select only the second harmonic (and higher order) resonant modes, in just those dimensions you wish to control. This strategy relates to placement of the upper bass control Tube Traps.

If you place bass Tube Traps along one wall, then they will absorb the fundamental and all harmonics of the room resonance mode that occurs in that dimension (with that one wall being the stopping end of that dimension). For example, placing bass Tube Traps along the back wall as discussed above will absorb the fundamental and harmonics of the room resonance mode occurring between the front and back walls, along the front to back dimension. But if you place these same Tube Traps at the ***halfway*** point along this same dimension (e.g. halfway from the front to the back wall), then they will absorb ***only*** the second harmonic (and all higher even order harmonics), while leaving the fundamental entirely untouched.

Why this magic property of selective absorption? The fundamental mode (and all harmonics) have their pressure maxima at the two opposing walls which create and sustain the resonance mode. Tube Traps work by absorbing when there is acoustic pressure. The fundamental resonance mode, being a half wavelength mode, has zero acoustic pressure at the halfway point between the two opposing walls creating and sustaining that particular mode. Thus, if you put some bass Tube Traps at the halfway point for a particular dimensional mode, there's no acoustic pressure there from the fundamental for the Tube Trap to absorb, and so it does not affect the fundamental low bass mode. Meanwhile, the upper bass second harmonic has full acoustic pressure at this point, so it is maximally absorbed.

Thus, by placing bass Tube Traps appropriately, you can selectively control and absorb upper bass boom, without further affecting lower bass quantity or quality (which you have already optimized to your taste using the low bass Tube Traps along the walls, as discussed above). The overall tactic is simply to place those bass Tube Traps, which you intend to control the second harmonic of a bass resonance mode but not absorb the fundamental, at the halfway points of the room dimension causing that mode. This is shown in Figure 2 as the two columns of Tube Traps located at the center point of each side wall; these work to control the second harmonic (upper bass boominess) of the room's front to back mode, without affecting the fundamental.

If you need even more control of the second harmonic of this front to back mode, we suggest a horizontal row of Tube Traps hung rom the ceiling across the room at the midpoint; this is also shown in Figure 2 (as the mid-room rectangle with the wavy lines). There might be circumstances in which you would want to install this horizontal row first, before trying the vertical columns at the midpoints of the side walls; that's because the side columns affect also the room's side to side resonance mode, and affect its fundamental, whereas the horizontal row affects this resonance mode less (while affecting the top to bottom resonance mode more). See immediately below for discussion of multiple mode considerations.

Tube Traps that you intend for control of the fundamentals as well. The bass Tube Traps for the second harmonic should be selected so that their bass cutoff frequency is lower than the frequency of the second harmonic for the appropriate room dimension, but it doesn't have to be lower than the room's fundamental frequency for that dimension (if it is lower than the fundamental, no harm is done, since its midpoint location won't affect the fundamental anyway — but you may have wasted money on a larger Tube Trap, unless you are also using that same midpoint Tube Trap for controlling the ***fundamental*** of the room's resonance in a ***perpendicular*** dimension).

In some circumstances, a listener might want to select and install bass Tube Traps to control only the room's upper bass harmonics, leaving the fundamental resonance modes alone. One example would be if relatively small speakers were used, with their resonance being slightly higher in frequency than the room's fundamental resonance modes. In this case, the room's fundamental resonances could be used to effectively extend the bass response and apparent bass power of the speaker (though the quality of this resonant ringing bass would be a compromise).

Note in this example that placement of the speakers in the room also plays a role in extending their bass capabilities, and in exciting the room's various fundamental modes. A whole treatise could be written on the compromise tradeoffs of speaker placement, keeping them far enough away from all walls (and the floor) for best stereo imaging and least colorations, yet close enough to these walls to pick up a loading advantage at bass frequencies from them, yet far enough away from these walls so as not to excite room resonance modes excessively.

A second example would be if very small speakers were used, with such a high frequency bass cutoff that they cannot even excite the room's fundamental resonance modes. If the fundamental modes are never excited, then you don't need to select or place bass Tube Traps to control the fundamental modes (other than perhaps the floor to ceiling mode, since this typically occurs along a short dimension and hence at an upper bass frequency). You can concentrate on controlling just the upper bass, second harmonic modes.

A third example would be applicable for many listeners of rock music. Rock recordings are typically EQ'd to boost their upper bass, but without enough lower bass in comparison. And a little extra low bass overhang can add visceral excitement to the rhythm, without hiding the music (as upper bass boom does). In this example, the listener might want to utilize the fundamental resonance modes of the room to enhance the low bass excitement, and control only the upper bass boom of the room's second harmonic modes.

A fourth example, mentioned earlier, is one in which you the listener simply prefer all the low bass quantity you can get, even if it is a bit soggy in quality. It's primarily upper bass boom that bothers you, and which you wish to control.

In these four examples (and perhaps other cases as well), it is desirable to control the far more audible upper bass boom, primarily from the second harmonic modes, and to leave the fundamental modes pretty much alone. How can you accomplish this? Interestingly, the best tactic is precisely the reverse of the typical bass Tube Trap setup. The typical setup places the bass Tube Traps only in the room corners. But the best tactic for controlling only the second harmonic upper bass boom is to place ***no*** bass Tube Traps in the corners at all. Instead, the four bass Tube Trap columns should be moved from those typical corners to the ***center*** point of each of the four walls. This center wall position is the one that controls the second harmonic mode the best while affecting the fundamental modes the least.

I have yet to see anyone try a bass Tube Trap installation with bass columns only at the center walls and none at the corners, but this tactic would be sonically preferable to some listeners, and appropriate to systems with smaller speakers. Note again that the correct bass Tube Traps for dealing with the second harmonic can be smaller models than the correct ones for dealing with the fundamental, thereby saving you some money.

— Multi-Mode Control

An ordinary rectangular room has of course not one dimensional mode, but three (rooms with alcoves, etc. have even more). So the above considerations, calculations, and placement tactics should be executed three times, one for each of the dimensions.

The optimum tactics for dealing with one dimensional mode might conflict with the optimal tactics for another dimensional mode. In some instances this conflict is easy to resolve. For example, the second harmonic of the length or width of your room might be very close in frequency to the fundamental of the height. But, since both are likely contributing to an upper bass boom, you can easily kill two birds with one stone; simply select bass Tube Traps with the appropriate cutoff frequency, and then run a horizontal row across the ceiling, at the midpoint of the dimension whose second harmonic you wish to control. In Figure 2, the horizontal row across the middle of the room works to control the second harmonic of the front to back dimension, while it also is at the end of the floor to ceiling dimension, thus helping to control that fundamental.

On the other hand, placing the same Tube Traps in vertical columns at the midpoint of the side walls (also shown in Figure 2) places minimal Tube Trap area at the ends of the floor to ceiling dimension, so it hardly affects the vertical room modes at all (meanwhile, however, it affects the fundamental of the side to side room mode more than does the horizontal row of the same Tube Traps hung from the ceiling).

Once you have understood the basic strategies of bass Tube Trap selection and placement, it becomes pretty easy to place each set of bass Tube Traps so that it controls the one room mode dimension the way you want it controlled, and then affects the room modes of the other two dimensions maximally or minimally, as you wish. Just remember that, because you're dealing with a three dimensional room, each bass Tube Trap location will inevitably affect the two other dimensions besides the one you're focussing your attention on. By intelligent placement, you can make that Tube Trap affect the second dimension minimally and the third dimension maximally, or vice versa as you choose, while still accomplishing the desired control for the first dimension. Remember throughout that the fundamental modes can be damped by bass Tube Traps along just one of the two opposing surfaces causing that mode; you don't need to damp both ends, and this will afford you more flexibility in placement.

We have concentrated on discussing control of the fundamental and second harmonic modes of the room. What about higher frequencies? As noted, bass Tube Traps at the end of a dimension act to absorb not only the fundamental and second harmonic, but also the third harmonic and all higher harmonics. The bass Tube Traps at the midpoint of a room dimension harmonic, but also the third harmonic and all higher harmonics. The bass Tube Traps at the midpoint of a room dimension act to absorb not only the second harmonic (while leaving the fundamental alone), but also all higher even order harmonics. However, in most rooms the third harmonic, and certainly the fourth harmonic, will already be higher in frequency than the upper bass, and will be in the warmth region. In this frequency region we have to start worrying about reflection control (see section below), which involves considerations far beyond room resonance modes (for example, it involves the typical distance of speakers and listener to the side walls, etc.). Thus, we recommend that you worry only about the low bass and upper bass when paying attention to room resonance modes.

Additional considerations apply to the bass Tube Traps in the front corners of the room (the speaker end, shown as the top of the plan in Figure 2). These Tube Traps should actually be selected to match not the room modes, but rather the bass characteristics of your speaker. The bass control of these Tube Traps should be adjusted to match the bass cutoff of your speaker, its bass Q, its need for bass boost from nearby surfaces or corners, and the distance from the speaker back to the corner. These factors might well call for the use of skinnier Tube Traps than the room mode dimensions would suggest, thereby saving you money (this is why we show these front corner Tube Traps as being possibly smaller circles).

There are no simple rules for optimizing these front corner bass Tube Traps. The basic goal is to keep this corner from excessively talking back from the speaker's bass rear radiation (speakers are omnidirectional in the bass). Excessive talk back will cause an amplitude hump plus a ringing boom at some frequencies (depending on the speaker to corner distance) and a cancellation at other frequencies, with bass phase shift at the frequencies in between (see Hotlines 39 and 40 for discussion). But your speaker might have been designed to depend upon some bass support from nearby (i.e. three to five feet away) surfaces or corners, especially if it's a small or low Q bass system. If this is the case, you'd want to damp corner talk back above the speaker's resonance frequency, but not below, so select Tube Traps for the front corner whose bass cutoff is just a bit higher than your speaker's bass resonance.

Incidentally, if your speaker needs corner boost for bass, and still sounds lean in the warmth region, you might try an even skinnier Tube Trap in the front corners, one having a bass cutoff that is not slightly higher but rather much higher than your speaker's bass resonance frequency. There should be some sort of Tube Trap in the corner to at least control corner talk back in the lower midrange, where it could cause bad honking colorations (the Tube Traps that we will place directly in back of the speakers are even more important in this regard; see below).

Smaller speakers , those requiring a stand, can also benefit from your using a full round, 2 or 3 foot high Tube Trap as a speaker stand. Select the Tube Trap model whose bass cutoff will or won't attenuate your speaker's fundamental resonance, as you wish. Line up the seam with the front of the speaker.

On the other hand, if your speaker is a large system designed for full bass in a free field, then it doesn't need any help from a nearby surface or corner, and indeed it will probably sound too bass heavy and boomy unless you do fully damp the nearby corner, down to below the speaker's resonance frequency. In this case, select front corner bass Tube Traps with a cutoff frequency at least as low as your speaker's bass resonance.

It's obvious that a lot of experimentation and listening, with various Tube Trap models, is necessary if you are going to truly optimize the bass performance of your room for your taste and your speakers. Hopefully, your ASC Tube Trap dealer will be prepared to help you, perhaps lending you additional bass Tube Traps so you can try different configurations and discover which you prefer. If you only buy a limited number of bass Tube Traps, you might well never discover whether bass control can get even better in your room with just one more bass Tube Trap column in some location, say some center wall position.

Scientifically speaking, you can never know whether you have optimized bass performance of your system (including your room) unless you go beyond the optimum for your taste, and then back off. This fact necessarily implies that you should try listening to more bass Tube Traps than you will wind up buying. And that in turn implies that an intelligent ASC dealer should be prepared to lend you extra bass Tube Traps to try (it's a wise business move for him too; you will surely be buying more bass Tube Traps than otherwise, once you hear the sonic improvement from that extra bass control from additional bass Tube Traps).

If perchance you are not near an ASC dealer, we suggest you follow the various considerations discussed with respect to Figure 2. You don't need to emulate all the bass Tube Traps shown in Figure 2 unless you have large speakers and like high quality bass. You can, if you wish, emulate only those parts of Figure 2 that pertain to you, as indicated by the discussion above.

Perimeter Reflection Control —

The above sections dealt with bass control and room resonance modes. These phenomena take place ***between pairs*** of room surfaces (again, it takes two to tango).

But that is only one facet of the sonic magic that ASC Tube Traps can achieve for your listening room and your musical enjoyment. Tube Traps can improve many other sonic aspects.

These other sonic aspects relate to reflections. Reflections occur from ***single*** walls, and do not really depend upon a pair of opposing walls. Reflections therefore occur wherever there is a single wall or surface in your listening room. Consequently, in order to control these reflections, you must use Tube Traps wherever there are room surfaces, in other words, along all walls and the ceiling.

If you control reflections correctly in your listening room, whole new worlds of sonic magic will open up to you. The typical application of Tube Traps, for just bass control, is but a small slice of the rich pie representing the multifaceted sonic capabilities of Tube Traps. What are some of these other sonic capabilities? They were discussed extensively in Hotlines 39 and 40, but for your convenience we'll briefly go over the highlights again.

The most unique sonic capability of Tube Traps is in controlling the dreaded mud factor. The mud factor is an echoey blur your room imposes on music, primarily in the warmth and lower midrange regions. It's too high in frequency to be heard as an upper bass boom, but too low in frequency to be heard as a midrange honk or upper midrange glare. In fact, it's hard to hear its presence at all. But everyone can easily hear its absence.

When you remove the dreaded mud factor from a room, music becomes dramatically clearer, more dynamic, and more alive and sparkly. Gone is that sensation of needing to keep turning up the volume, trying in vain to get the music to sound clearer and more dynamic. The music sounds as if it had been literally lifted out of a sea of obscuring mud and rinsed clean, when you use Tube Traps to control the mud factor.

This sonic capability is unique to Tube Traps because only Tube Traps can absorb sound below 400 hz, covering the critical mud factor region of 100 hz to 400 hz. Wall panels of acoustic foam or fiberglass are ineffective below 400 hz, so they cannot control this dreaded mud factor.

Tube Traps also are superb at eliminating hot spot wall reflections that cause obscuring smear plus tonal colorations in the midranges. These colorations are chiefly audible as a midrange honk and upper midrange glare. They might sound as though they are originating in your speakers, but often it is your room surfaces that are the culprit. Using Tube Traps to control these hot spots makes music sound more neutral. It also makes music sound again much clearer and more dynamic, as it is freed from an obscuring sea of smearing midrange echoes.

This Tube Trap control of midrange hot spot reflections will also dramatically improve all aspects of stereo imaging. That's because these same hot spot reflections represent a temporally coherent packet of energy that arrives at the ear/brain from a different direction than the direct sound from the loudspeaker, and at a different time. This degrades stereo imaging, especially if this hot spot coherent packet arrives within 15 milliseconds of the direct sound (which it will, unless your room is so large that both speakers and listener are more than 10 feet away from the nearest wall or ceiling surface).

The research by Haas and Damaske demonstrated that stereo imaging (and musical transparency) can be enhanced if reflected energy heard by the ear/brain is ***incoherent***, nondirectional (coming from many directions at once and not concentrated from any one direction in particular), and arrives more than 15 ms after the direct sound. Reflected sound that fails to meet these criteria is detrimental to stereo imaging, and can even blur and obscure the original music.

Therefore, you don't want to eliminate reflected sound entirely. An acoustically dead room will not support a rich stereo image from a two speaker stereo system. Indeed, some reflection from virtually all parts of the room's surfaces is vital to achieving a uniform yet randomly incoherent reverb decay characteristic for your room, which enhances both stereo imaging and the rich heft of dynamic sonority. Thus, you want to control reflections throughout the room surfaces, but not totally eliminate them anywhere.

The secret to Tube Traps' success in accomplishing this desideratum is twofold. First, they are very effective absorbers where they are located, which allows you to leave wall area bare between them, thus obtaining some full spectrum reflection from all areas. In contrast, surface mounted absorbers of foam or fiberglass are less effective absorbers, so you need to cover more wall area for the same absorption control, thereby leaving less area to support those enhancing reflections.

Second, Tube Traps allow tunable reflection directional control, which is vital for optimizing the various aspects of stereo imaging (see discussion below). In contrast, surface mounted absorbers are not tunable for direction.

— Basic Setup

To obtain all these additional sonic benefits available from Tube Traps, the basic tactic is simplicity itself (which should be a welcome relief from the complex considerations involved above for bass control). You can accomplish reflection control, for the entire perimeter of your room, by simply placing a 9 inch Tube Trap column (the skinniest and least expensive) every 3 feet or so around the perimeter of your room (except for the locations where you have already installed bass Tube Traps for optimizing bass control).

Figure 3 shows such an installation, including the bass Tube Traps from Figure 2, plus the added 9 inch Tube Trap columns for reflection control around the perimeter of the room. If by chance you did not fill all of the locations of Figure 2 with bass Tube Traps for bass control, then these locations should be filled now with 9 inch Tube Trap columns for reflection control (that includes at least the two horizontal rows across the ceiling, which is also a surface requiring reflection control).

In fact, Figure 3 shows the general Tube Trap layout in the plan of our lab's master listening room, which is 30 feet long (front to back) by 25 feet wide, with a 14 foot cathedral ceiling. Most other listening rooms are smaller, so they would require fewer columns of 9 inch Tube Traps for adequate perimeter control.

Basically, we recommend that you place reflection control Tube Trap columns every 3 to 4 feet around the perimeter (use whatever distance within the 3 to 4 foot range that works out to evenly divide into your room's exact dimensions).

On the front wall, in back of the speakers, we recommend you place these columns every 2 to 3 feet; or perhaps, just in back of each speaker, place an extra column or shorten the distance between columns somewhat. The reason is that energy from the speaker going straight back to the front wall, and then reflected straight back toward the listener, is especially detrimental in terms of time smearing and degrading spatial imaging.

We use only two horizontal columns across the ceiling, because our ceiling is very high and pitched, so it does not create severe reflection problems. But a low and flat ceiling would create severe reflection problems, and so would require more horizontal rows, perhaps even a row every 3 to 4 feet, spaced to match the columns along the side walls.

In addition, we have found that it helps coherence and stereo imaging to have a pair of columns placed physically halfway between the speakers, about 6 inches from each other, as shown in Figure 3. This finding owes a debt of thanks to Monster Cable, who marketed an acoustically absorbent dividing screen for just this purpose.

Our pioneering article on ASC Tube Traps in Hotlines 39 and 40 introduced this concept of perimeter reflection control, and discussed its importance. Even the manufacturer of Tube Traps had not recognized the virtues of using his product in this manner. Since then, a number of high end listening rooms have employed this strategy, with impressive sonic results. In fact, a room so completely treated with Tube Traps for perimeter reflection control has become known in the industry as a Moncrieff room.

On a recent visit to Italy's top high end dealer, Absolute Sound, we witnessed such a room, and with some fine tuning using our trained ears, we were able to obtain superb sonics and imaging from Goldmund's premier system set up in this room (the room did have a low ceiling, and did not have the required horizontal rows on the ceiling to control this, but otherwise had excellent perimeter reflection control).

Placing 9 inch Tube Trap columns every 3 feet or so is necessary to control the dreaded mud factor. Why? Recall that the mud factor predominates from 100 hz to about 400 hz (where surface mounted absorbent foam or fiberglass is totally ineffective). The wavelength of 500 hz is about 2.25 feet. Thus, placing perimeter control 9 inch Tube Trap columns every 3 feet, leaving 2.25 feet of blank wall space between columns, breaks up every ***other*** half wavelength up to about 500 hz. A half wavelength is the shortest amount of an acoustic wave that can reflect, at the pertinent frequency.

It is undesirable to allow several half wavelengths to accumulate along a reflective wall; this would create a coherent reflected packet of sound from that segment of the wall (or ceiling). One example is shown as the arrow in Figure 3, coming from the left speaker and reflecting from the side wall toward the listener (such coherent reflection packets would occur from all surfaces around the perimeter, unless they are controlled). This coherent reflected packet would be heard as a distinct sound source, which smears the music signal both temporally and spatially, creating obscuring mud and degrading stereo imaging. Recall that incoherent random reflections are valuable sonic assets, but coherent directional energy packets of reflected sound are detrimental.

Is a 3 foot spacing close enough? It seems to be. Breaking up every other half wavelength seems adequate to insure that no large coherent packet of sound will be reflected from any one spot around the room's perimeter. This spacing seems adequate to control the mud factor, between 100 and 400 hz.

Above 500 hz the wavelengths are short enough so that the blank wall space between columns would reflect some coherent packets. But two other factors come into play to alleviate potential problems above 500 hz. First, these shorter wavelengths tend naturally to bounce all over the room more randomly, hence to become randomly incoherent by themselves. Second, the round shape and 9 inch dimension of each Tube Trap column begin to aid in this random scattering of the shorter wavelengths above 400 hz, because this is the frequency where the Tube Trap's reflective side begins to reflect, and also begins to act as a cylindrical diffuser (this diffusion takes full effect at all the frequencies above where the 9 inch diameter is itself equivalent to half a wavelength, which is 550/.75 = 733 hz). Thus, frequencies above 400 hz, and certainly above 733 hz, are randomly scattered into incoherent reverberant energy which helps the music and the stereo imaging, rather than harming them.

In sum, it is both necessary and sufficient to place Tube Traps every 3 feet or so around the room (and perhaps across the ceiling), for adequate perimeter reflection control of frequencies above 100 hz. Incidentally, we recommend leaving the room walls absolutely bare behind the Tube Traps, so they are fully reflective of higher frequencies wherever the Tube Traps aren't. If the resulting room acoustic is too bright for your taste, with all Tube Traps in place, then you can hang some attractive soft surface absorbers on the walls between (and behind) the Tube Trap columns.

— Validating Perimeter Control

We've written before about the amazing power and sensitivity of Tube Traps in sonically affecting all those sonic aspects that benefit from proper perimeter reflection control. We can often hear the difference if one Tube Trap column is moved a fraction of an inch, or rotated a fraction of an inch.

But many of you are probably looking with trepidation at all the Tube Traps involved in emulating Figure 3 for your room. The budget requirements are not inconsequential. But think of all the money invested in your library of music recordings and in your stereo system. What's it worth to hear all this investment at its proper potential for a change? It might also seem strange to be surrounded by a veritable forest of Tube Traps. But our listening room has the comforting feel of an open Greek temple, with the columns around the perimeter.

Still, you might be doubting that all those Tube Trap columns are really necessary. So we conducted a measurement experiment, to prove to you that every one of those Tube Trap columns is necessary, to achieving adequate perimeter reflection control for the room. The proper scientific method for proving this thesis is to fully treat a room, and then remove just ***one*** Tube Trap column. This should make a very small difference, but just enough of a difference to test whether every one of those Tube Trap columns is truly necessary.

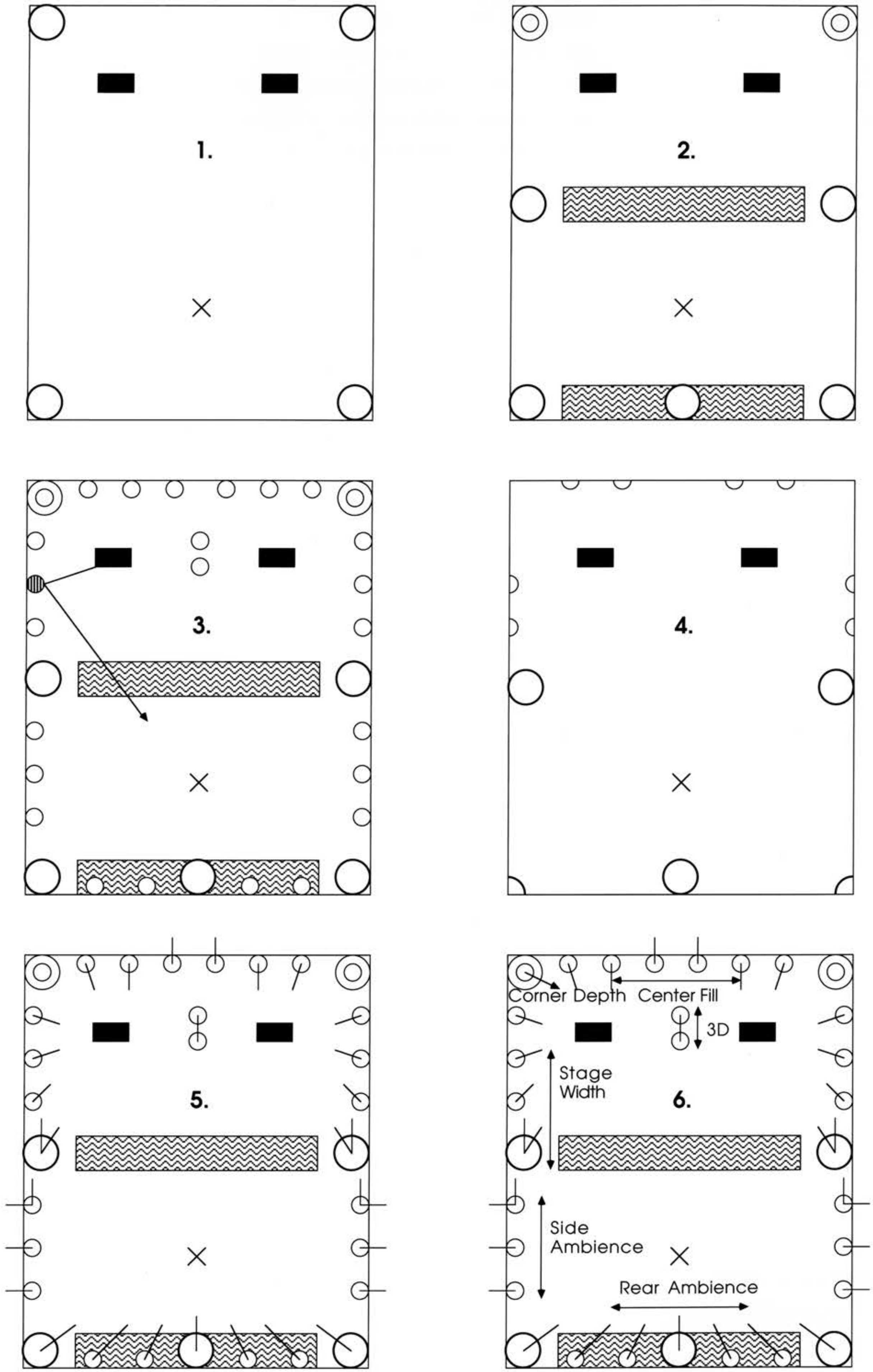
So that's the experiment we performed. We removed just one 9 inch Tube Trap column used only for perimeter reflection control (the one shown with stripes) from the complete room setup shown in Figure 3. We set up the measuring microphone along the listening path, between the wall reflection point shown and the listener. It's an omnidirectional microphone, so it would be measuring the total room behavior, as heard along this path.

When the one Tube Trap column is removed, there is one 5.25 foot gap between Tube Traps, with all other gaps being 2.25 feet as recommended; when it is replaced, this 5.25 foot gap is eliminated, and is replaced by two of the recommended 2.25 foot gaps. Would there be a measurable difference in the room from the elimination of just one Tube Trap column from the total set of 33 columns we had installed for total perimeter control?

If there was to be a difference, it would probably show up in that dreaded mud factor region, somewhere between 200 hz and 400 hz. That's because we would be allowing one unprotected gap in the room's entire perimeter, a gap of 5.25 feet to be precise (6 feet minus the 9 inch diameter of the columns themselves). That gap would have the capability of sustaining a coherent reflection packet of two half wavelengths, or three, four, etc. Two half wavelengths within 5.25 feet calculate out as equivalent to 210 hz. Thus, by exposing an unprotected gap of 5.25 feet, we would expect to see some room troubles somewhere above 210 hz, troubles which would be cured by controlling that gap and narrowing it to the recommended 2.25 feet. If, that is, every single Tube Trap column (with 2.25 foot gaps) were truly important to adequate perimeter reflection control in this room.

Incidentally, because this is a huge room, the effects of removing one column out of 33 should be much smaller upon the huge room than the effects upon a smaller room of removing one column out of say 20. So the results we prove here will be even more relevant to smaller rooms.

The standard time honored test for echoes, smearing, and resonances is the tone burst test. ASC makes available a convenient cassette, which contains a range of tone bursts spanning the relevant frequencies of 20 hz to 755 hz (technically, the tape contains a sine wave that slowly slides in frequency,


1.
2.
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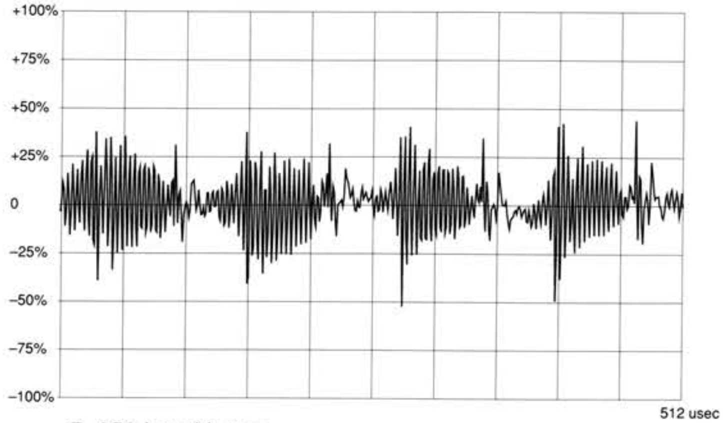
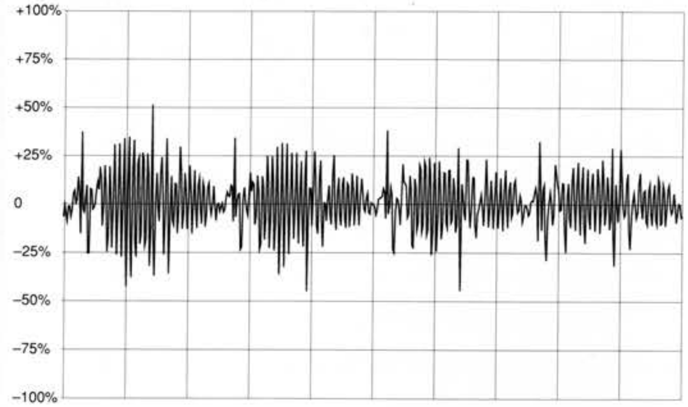
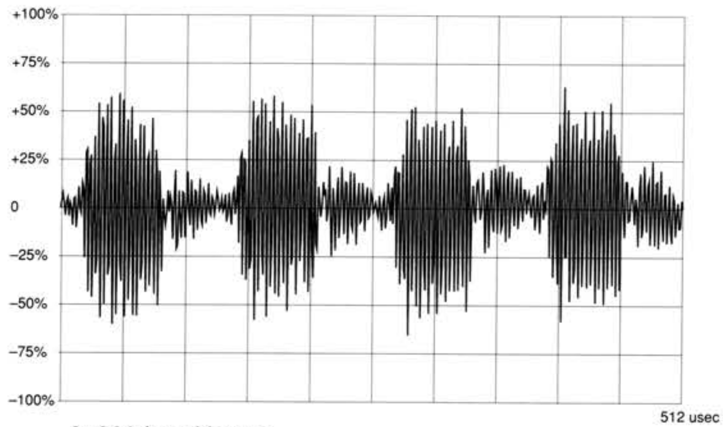
Corner Depth
Center Fill
3D
Stage Width
Side Ambience
Rear Ambience



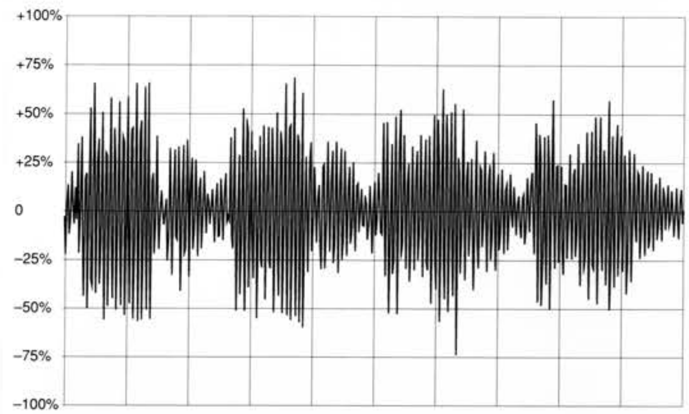
7. 250 hz with trap



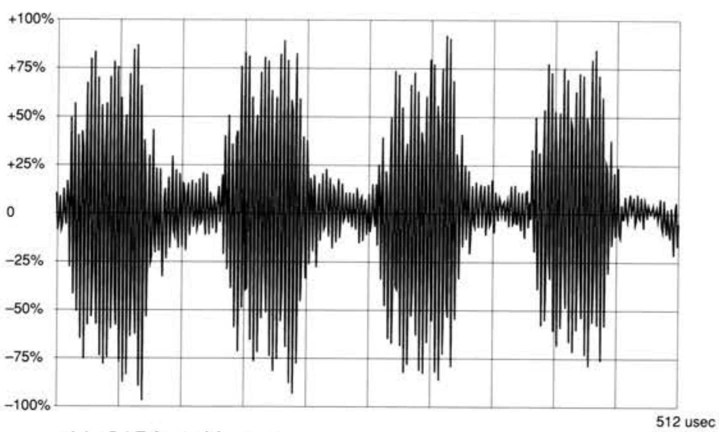
8. 250 hz without trap



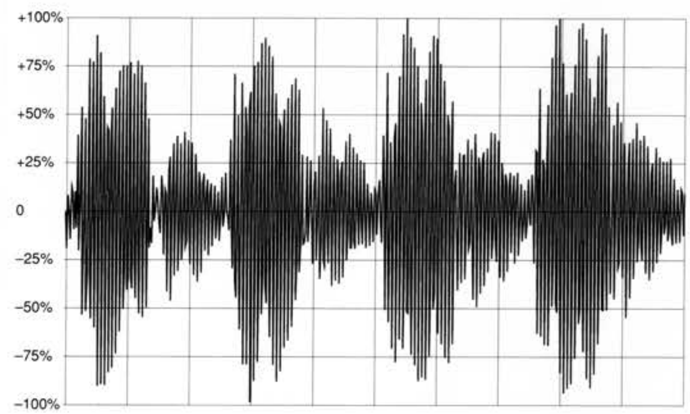
9. 300 hz with trap



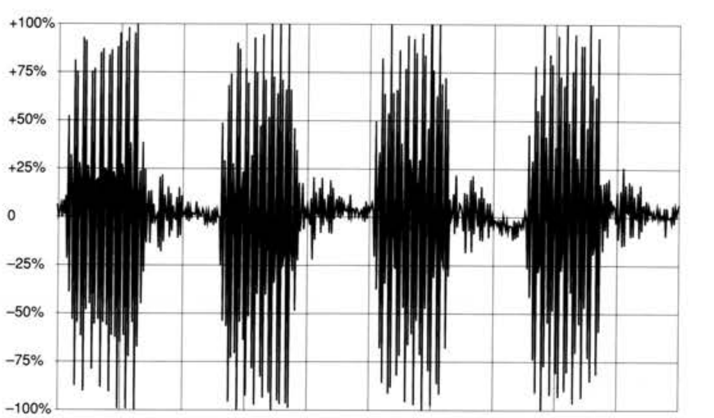
10. 300 hz without trap



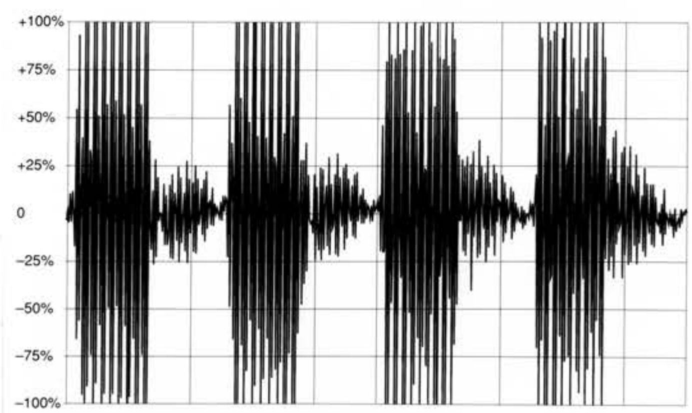
11. 315 hz with trap



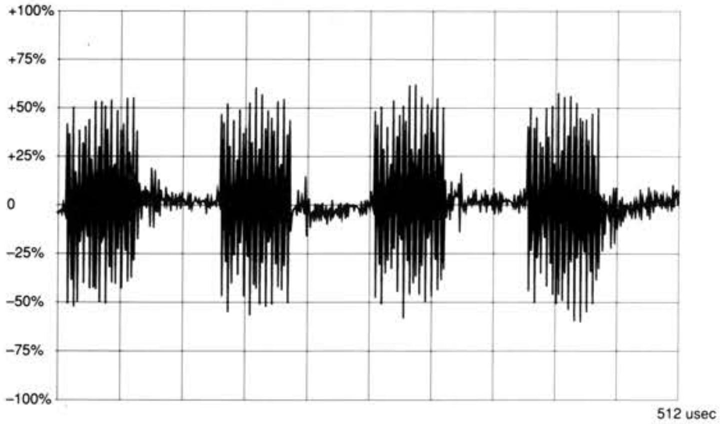
12. 315 hz without trap



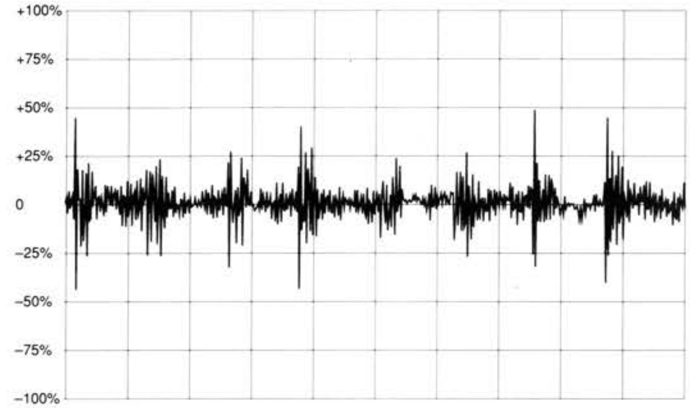
13. 420 hz with trap



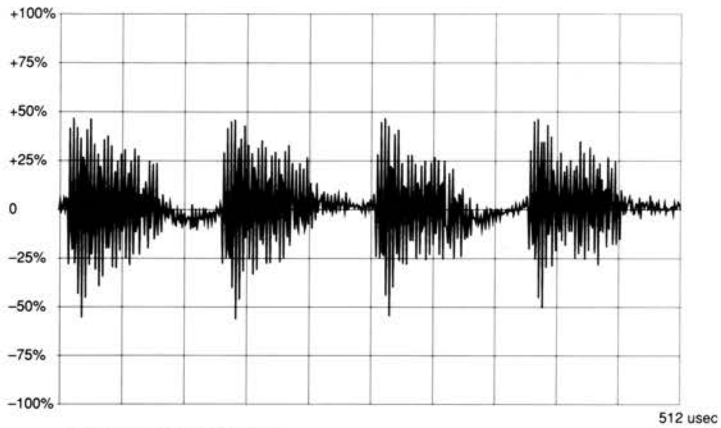
14. 420 hz without trap



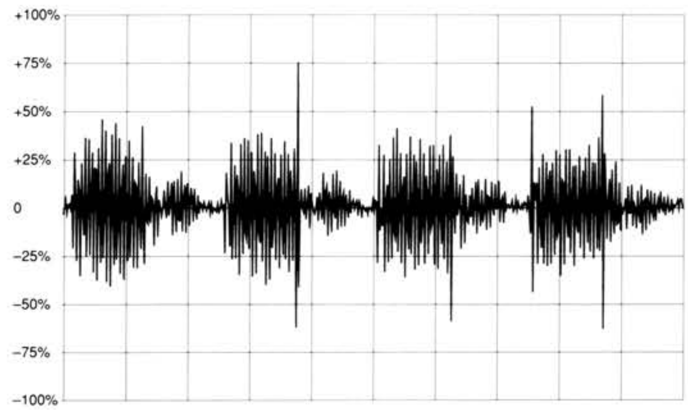
15. 600 hz with trap



16. 600 hz without trap



17. 630 hz with trap



18. 630 hz without trap

and then is chopped into 8 tone bursts per second). The perfect tone burst response should look like a solid rectangular block of full amplitude sine waves, followed by a period of silence (of the same duration as the rectangular block, on this tape), followed by another rectangular block of full amplitude sine waves, etc. Figure 15 shows a pretty good looking example. Each picture show 4 tone bursts, with 4 supposedly silent periods. Note that each of the 4 tone bursts in a picture will be slightly different, since each represents a slightly different frequency from the sliding sine wave tone.

Incidentally, don't pay attention to the irregularities you'll see in what should ideally be a flat top and bottom of each tone burst's rectangular block; they are mostly random artifacts of measurement in a reverberant room. Also, you should naturally expect to see some reduction in the amplitude of every main tone burst when we add the absorbent Tube Trap in the reflective path.

What then do you look for in this tone burst measurement? The most important thing to examine is how well the room falls to silence after each rectangular block of tone burst. The tone burst itself mimics a musical transient or any piece of musical information. After that musical transient or piece of information is over, the room should not continue with too much energy as smearing echoes. If it does, these smearing echoes of the room will form a sea of mud, the dreaded mud factor.

This sea of mud will obscure the end of the musical transient (and the subtle after resonances that tell you about the texture, timbre, and material of the musical instrument); it will obscure the next transient or piece of musical information; and it will generally blur all the distinctions among various musical transients and pieces of information, as the music vainly struggles to rise above the sea of mud. The music's temporal coherence and even basic clarity will be lost in this sea of mud. You'll want to turn up the music's volume for more clarity, but this won't help, since the sea of mud will also rise. In addition, if the smearing echoes are from a coherent reflection packet (as is the case here), it will degrade stereo imaging and cause tonal colorations.

You'll see this sonic description of a sea of mud vividly illustrated in some of the measurements. In some cases, the sea of mud rises so high relative to the music (represented by the rectangular tone burst) that it will be difficult to even see where each tone burst supposedly stops and restarts (for example the 3rd and 4th bursts of Figure 10).

Sometimes, as the sea of mud between rectangular tone bursts rises, you'll also see the amplitude of the rectangular tone burst itself diminish. This might be caused by cancellations occurring, where the undesirable packet of coherent reflected energy interferes with the direct sound from the speaker.

Sometimes the main tone burst is so diminished, or the sea of mud after the tone burst rises so high, that again you won't be able to see where each tone burst itself is supposed to begin and end (for example Figure 16). That is true room garbage, playing just as loudly as the original music signal. The sea of mud has risen to swamp the music. When you see this happening to our lab room from just the removal of one Tube Trap column out of 33, you'll realize graphically just how important each and every Tube Trap column is for adequate perimeter reflection control, for giving you clear music instead of mud.

ASC calls this tone burst tape the Music Articulation

Test Tape (MATT), with good reason. You can use this tape yourself, even without our fancy lab test equipment; all you need are a set of headphones and your ears. Borrow this tape from your ASC dealer, and simply listen to the test tone bursts first through headphones and then through your speakers. Through the headphones you will hear clear bursts of tones. Through your speakers you will hear smearing echoes after each burst, getting much worse at some frequencies. What you are hearing is the sea of mud contributed by your room. Your room is doing that to all your music. And you can fix it with Tube Traps, using them for full perimeter reflection control.

Now on to the measurements. As expected, removing the single Tube Trap column caused more problems at some frequencies than at others. Here is a selection of the most illustrative examples. We predicted that, if the perimeter reflection control thesis were correct, we should see the first problems somewhere above 210 hz. Sure enough, the first major difference cropped up around 250 hz (all frequencies are approximate, because of the sweeping nature of the test tone).

Figure 7 shows the room's performance around 250 hz with all Tube Trap columns in place; Figure 8 shows exactly the same signal, measured at the same point, with just the one Tube Trap column removed out of 33. Figure 8, without the single Tube Trap column, shows a lot of smearing echo energy lingering after each tone burst stops, with only a brief moment of relative quiet before the next tone burst begins. The tail of smearing mud is so large in its beginning that you cannot even tell where the original tone burst itself stops. With the controlling Tube Trap column restored to its place, Figure 7 shows that the smearing echo is reduced, and there is a much longer, better quiet period before the next tone burst begins. Of course, it's still not perfect (you can see two small single slaps of energy left in the time domain after the tone burst), but there's an easily visible difference.

The fact that some imperfect echo smear is seen even with the Tube Trap in place simply means that our room is still not perfect. The important point is that there is a clear difference, a clear degradation, when just one column of a complete 33 column perimeter reflection control setup is removed.

Figures 9 and 10 show a difference evident around 300 hz. In Figure 10 (without the Tube Trap column) you can see a large lingering echo smear. For the 1st and 2nd bursts, the smear begins after a small gap of quiet following each tone burst. For the 3rd and 4th bursts, the smear is congruent with the tone burst (so you can't even see or hear where the burst or musical transient is supposed to stop), and the smear itself is in the shape of a decaying triangle. Figure 9 (with the Tube Trap column) shows a smaller, better controlled version of this echo smear.

Figures 11 and 12 show a difference found around 315 hz. Figure 12 (without Trap) shows a big, blotchy echo smear; for the 4th burst, the echo smear is again congruent, and has that decaying triangle shape. Figure 11 (with Trap) shows a smaller echo smear, which is also more even and well behaved (more like the random incoherent reverberation background noise that is actually desirable).

Figures 13 and 14 show a difference found around 420 hz, at the upper edge of the mud factor region. Figure 14 (without) shows a fat decaying triangle of echo smear, while Figure 13, though still not perfect, shows a much smaller decaying triangle of this echo smear.

Figures 15 and 16 show a difference around 600 hz, which may be a harmonic of the trouble seen at 300 hz. Figure 15 (with Trap) shows a pretty decent signal, while Figure 16 dramatically shows total degeneration without that one Tube Trap column. The main tone burst signal collapses down to noise level in the middle of itself, probably due to some path length cancellations. It's hard to tell which is the inter-burst smear and which is the mid-burst collapse.

Figures 17 and 18 show a difference around 630 hz, which may be a harmonic of the trouble seen at 315 hz. Figure 17 (with Trap) shows pretty good silence in between tone bursts, with the visible residual noise perhaps representing just the desirable random incoherent room reverb. Figure 18 (without Trap) shows a larger amplitude of echo smear, in the form of a triangular decaying tail.

These measurements provide clear, indeed dramatic visual proof of the sonic importance of even one Tube Trap column to total perimeter reflection control in your room. They show the mud factor already rising, in the predicted warmth and lower midrange regions, when just 1 out of 33 perimeter control columns is removed. They show the importance of placing a Tube Trap column every 3 feet or so, as recommended, instead of wider spacing. We rest our case.

— Economy Version

If your room is smaller than ours, you won't need as many Tube Traps for a complete perimeter reflection control system. But even this might be out of reach of some of your budgets. If so, don't give up. Some Tube Traps are better than none. But which are the most essential Tube Traps for a minimalist economy system? Our recommendations are shown in Figure 4.

Let's start again with controlling the bass fundamental. The three bass Tube Trap columns shown at the back of the room (bottom of Figure 4) accomplish this. These should probably be 16 inch models, depending on your room length, with the center rear being perhaps a Super 16.

We've shown 16 inch quarter round models in the rear corners; they are much less expensive, while still offering good absorption down to low frequencies. You can save more money by using only a single Tube Trap at each location instead of a stacked set making a full floor-to-ceiling column, but of course this will not absorb as much energy (which might sound better for your taste in low bass).

Bear in mind that the more economical half and quarter round Tube Trap models come only in 5 foot high sections, while the full round models (preferable because they offer rotational control of perimeter reflections) come in your choice of 2 or 3 foot high sections.

If your taste or circumstances suggest that you do not want to control the lowest bass resonance fundamental at all, then you can eliminate these three back wall bass Tube Trap columns entirely. But then you should still retain some absorption directly in back of the listener for the warmth region and higher frequencies. The most economical model for this would be the 9 inch half round, which is a single 5 foot high unit (however, you might still want to retain a bass Tube Trap at this center rear position for controlling the upper bass boom of the room's second harmonic side to side mode; see below).

Note that the half round models are available in three versions: with the high frequency reflective strip in the center, or offset to one side, or none at all. In this back wall location, use the version with no reflective strip.

Figure 4 also shows bass Tube Trap columns at the midpoints of the side walls. These are to offer additional control of upper bass boom, beyond that afforded by the three bass columns at the back of the room. These columns can be a step down from the models at the back of the room, since they absorb the second harmonic rather than the fundamental of the front to back room mode (on the other hand, you might want to use these side columns also for more control of the fundamental of the room's side to side mode, in which case you should select the Tube Trap model with a bass cutoff low enough to include the frequency of the room's side to side fundamental).

If you don't want more control of upper bass boom beyond that accomplished by the three bass columns at the rear, then these midpoint columns can be changed to the more economical 9 inch half round model (use the version with the offset reflective strip, and orient the Trap so the reflective strip points toward the back of the room).

If you have decided to eliminate control of the front to back fundamental, by deleting the three bass Tube Traps at the rear, then it will surely be important to retain these side midpoint Tube Trap columns as bass units, in order to control the upper bass boom of the second harmonic of the front to back mode. Similarly, it would then also be important to retain the center rear column as a bass Tube Trap, in order to control the upper bass boom of the second harmonic of the side to side mode (you might even want to add a bass Tube Trap column at the center front wall of the room to help in this; such help may be needed because you have eliminated the rear corner bass Tube Traps, which worked to control the side to side second harmonic as well as the fundamental).

So much for bass control; now, on to reflection control. It's important to provide reflection control directly in back of the listener (as already discussed) and also the speakers. These are straight reflection paths which would degrade temporal coherence of the music, ruin imaging, cause tonal colorations, and contribute to the mud factor. These reflective paths should be short circuited for the full spectrum, from the warmth region up. To accomplish this, use 9 inch half round models (preferably full ceiling height columns, but it would suffice to use single 5 foot high units, which are as tall as the speakers in front and as the seated listener's ears in back). Use the version with no reflective strip.

As we saw in the measurements above, it's also important to control the angled primary reflection paths from the speaker to the side wall to the listener. This is accomplished by using two half round 9 inch models per side, as shown in Figure 4. Use the version with the offset reflective strip, and orient the Tube Traps so that the reflective strip points toward the back of the room (bottom of the picture). The reason for this orientation is that we want these reflection control Tube Traps to fully intercept and break up the sound coming directly from the speaker, which will arrive at the front side of the half round. But the rear side of the half round encounters random incoherent reverberant energy (Damaske effect)that has already been around the room and so is significantly delayed (Haas effect); this energy we want to encourage, by diffusing and reflecting it further.

Note again that, if you have chosen to eliminate the bass Tube Traps at the midpoint of the side walls, then these too should be converted to the 9 inch half round model, with the offset reflective strip pointed toward the back of the room. This would make three half rounds along each side wall, unless you have a small room, in which case two on each side might do (a handy rule of thumb is this: start just forward of the speakers along the side walls as shown, then space them every 3 feet or so, and stop before you get to the side of the listener, as shown).

Figure 4 does not show any Tube Traps hung horizontally across the ceiling. If your ceiling is flat, it may be important to also include some rows across the ceiling. The model you select depends upon the problem being addressed. If there is some upper bass boom from the floor to ceiling mode, then a row of bass Tube Traps hung across the center of the room will help. If there is still too much mud factor, then some half round rows across the room should help; mount them to the ceiling just where you've placed the half rounds along the side walls (with their reflective side also pointed towards the back of the room).

This economy Tube Trap setup won't sound nearly as subtly refined as the full fledged setup of Figure 3, but it will provide most of the basic sonic benefits to some degree. That's a lot better than the typically seen setup of just four Tube Trap columns in the corners.

— Alignment of Tube Traps

ASC Tube Traps are designed to absorb the full frequency spectrum (down to their bass cutoff) on one side, but to reflect and diffuse most of the frequency spectrum above 400 hz from their other side. That engineering feature becomes a very powerful and flexible tool for precisely adjusting perimeter reflection control.

Recall that we spaced Tube Trap columns about 3 feet apart to control the mud factor, between 100 hz and 400 hz. The entire spectrum above 400 hz, including the midrange and trebles, is a different matter entirely. It consists of short wavelengths which are directional, and which can be directionally steered to sonic benefit, rather than simply absorbed everywhere.

By simply rotating the cylindrical Tube Traps, you can determine how all frequencies above 400 hz will be steered in your room (with the half round model, you are more limited, and you must preselect and orient the reflective direction if any). The subtlest change in rotation of any cylindrical Tube Trap in the room can make a significant difference in truly optimizing the sound of your system (that's why we recommend the full round rather than half round models, if you can afford them).

Rotating Tube Traps to absorb energy (above 400 hz) on short primary reflection paths (within the Haas window) can work wonders to improve stage imaging and coherence, and eliminate glary hot spot colorations. And rotating Tube Traps to reflect and diffuse later reverberant energy on long secondary, tertiary, etc. paths can work wonders to improve imaging ambience and depth.

The basic strategy is shown in Figure 5. The line radiating from the center of each circle represents the seam sewn along the length of each Tube Trap; this is the direction of maximum high frequency absorption. The setup shown in Figure 5 will give decent performance, but it really intended just as a starting point, from which you should further fine tune by ear. If you have also installed any horizontal rows across the ceiling, they should be rotated to point similarly into the room as the equivalent Tube Trap columns at that point along the side wall, and then fine tuned from that starting point.

The rationale for the rotation orientations shown in Figure 5 is as follows. The Tube Traps immediately surrounding each speaker are set for maximum absorption at all frequencies. Here the primary reflected path is short (well within the Haas window), so reflected energy would degrade coherence, smear the music, cause tonal colorations, and ruin stereo imaging. The same is true for the Tube Traps immediately in back of the listener.

The other Tube Traps along the back wall, off to either side of the listener, are more flexible. They are shown pointing toward the listener, but you might prefer the sense of added hall ambience you might get by rotating them somewhat away from the listener, or even with the seam pointing directly into the wall. Likewise, the Tube Traps along the front center wall (off to the side of the speakers) are flexible in rotation. We prefer them pointed straight into the wall as shown; the reflected diffusion this offers seems to help the center fill and liveliness of the stereo stage.

The pair of Tube Trap columns precisely between the speakers is also flexible in orientation. We prefer them pointing directly at each other, for minimum upper frequency absorption and maximum reflected diffusion.

The sets of Tube Trap columns along the side walls that are off to the side of the listener are an interesting case study. The Damaske effect says that you can best hear the hall ambience in a recording when randomly diffuse incoherent information is presented at the side of the listener's head. Thus, all Tube Trap columns along the side walls (and rows across the ceiling) are rotated to optimize the following two factors. Absorb those unwanted ***coherent*** packets of energy coming along the ***short*** reflected path from the speakers to the side walls to the listener (especially those that come at the listener from his front). And meanwhile reflect and further diffuse reverberant energy that has come on a ***long***, multiple reflected path and is already ***incoherent*** and delayed (especially that which will come at the listener from his side).

Meeting these two desiderata simultaneously yields the rotational alignments seen in Figure 5. If you look closely, you'll notice that the seams of the Tube Traps near the speaker along the side walls point almost perpendicularly into the room. Then, as you go backward in the room toward the listener, the rotational alignment of each successive column progresses toward having the seam point parallel to the side wall, and toward the front of the room.

This progression is in part a natural consequence of having each column point directly at the nearest speaker, for maximum absorption of the short path energy. But it also serves to present to the rear part of the room, and to the side of the listener, a progressively increasing amount of reflection and diffusion of the reverberant long path energy in the room. By the time we arrive at the column directly to the side of the listener, the seam is pointing directly into the wall, for maximum reflection and diffusion of reverberant sound here.

A further subtlety. You'll notice that some of the side columns are shown with two lines radiating from them. This indicates that the bottom Tube Trap is rotated to have its seam pointing more perpendicularly into the room, while the top Tube Trap has its seam pointing more parallel to the side wall, or more into the side wall. If your ceiling is tall enough so that you are using a stack of three Tube Traps per column, start off with the middle Tube Trap oriented the same as the bottom one.

Why do this varying rotation? Because the speakers and the listener's ears are closer to the room's floor than to the ceiling. Thus the unwanted short path that we want to absorb is handled by the bottom Tube Trap. Meanwhile, the top Tube Trap sees mostly long path energy that has already been through multiple reflections, which we wish to encourage. So we orient the bottom Tube Traps for more absorption, and the top Tube Traps for more reflection and diffusion. Feel free to explore the possibilities of setting other columns with different rotations for the bottom and top Tube Traps.

— Fine Tuning

Fine tuning of Tube Traps must be done by ear, not by formula. It requires a highly trained, sensitive ear, of someone who knows what to listen for, how to interpret it, and what corrective adjustments to make. Unfortunately, that is something we cannot teach you in a written article. Some professional consultants in the field have a lot of experience with Tube Traps, and you might wish to hire them for final fine tuning. If you can't afford that, here are some general hints to guide you.

Think of this fine tuning procedure not as serious business, but rather as an exploratory experimental game. Make only one type of change at a time, and learn what each change in itself sounds like. Learn what the sonic difference is when you rotate one Tube Trap (symmetrically on both sides of the room) by 45 degrees, then 10 degrees, then 1 degree if you can learn to hear it. Try moving the location of columns 2 inches one way along a wall, then half an inch another way.

The fine tuning of Tube Traps in the back (listener) half of the room affects mostly the sound of hall ambience from the recording, while the front (speaker) half affects mostly the imaging characteristics of the stage where the musicians are performing.

In general, you'll find that rotating Tube Traps so that the seam points more into the wall (giving more reflection and diffusion into the room) increases ambience and generally improves imaging. But if you do this too much, you might pick up hot spots of midrange glare, some loss of musical coherence, and some unevenness in what should be a continuous curtain of sound across the stage width and depth — so listen carefully for any degradation in these qualities.

Conversely, fine tuning only for the smoothest sound of the room can easily go too far and make the room too dead, thereby degrading ambience richness that comes from random incoherent long path reflections — so listen carefully for any degradation in this aspect.

The ideal balance is a room that is neither too live nor too dead. But it would be a sad oversimplifying mistake to think that all you are trying to balance is liveness vs. deadness. You are really trying to make the room ***dead*** for ***short*** path coherent reflected packets and ***live*** for random incoherent ***long*** path reverberation, at all frequencies. And even that is only the beginning. The other factors pertain to the manifold intricacies of optimum stereo imaging, as follows.

As you play with the Tube Traps along the back wall, listen for the changes in the sound of hall ambience (from a recording that is rich in this), especially the ambience that seems to come from the back of the hall. This is indicated in Figure 6 as rear ambience fine tuning. Play especially with those Tube Traps along the rear wall that are not directly in back of the listener. We suggest that you try pointing the top

Tube Trap seam of each column toward the back wall, while leaving the seam of the bottom one pointing toward the listener (for the short path vs. long path reasons discussed above).

The Tube Traps along the rear half of the side wall also affect the perceived hall ambience, especially how large the hall sounds from side to side; this is labelled as side ambience in Figure 6.

The Tube Traps along the front half of the side wall affect the perceived width of the stage, and also how seamlessly continuous the solid curtain of music sounds across this entire stage width. With speakers that image well, it should be easy to have the perceived stage extend beyond the speaker width, and even beyond your room side walls (because the absorption of these Tube Traps can help these side walls to effectively disappear for early reflections).

Listen carefully to all factors when doing this fine tuning. Too little absorption along the front half of the side walls will create discrete secondary sources at the side walls, which might seem to enlarge stage width, but won't do so in a seamless fashion, for there will be hot spots, with too much musical energy seeming to be located inside the speakers and right at the side walls; you want a continuous, seamless curtain of music across the stage, with instruments located at all points in a good orchestral recording.

The seamless stage curtain is also affected by fine tuning the Tube Traps along the center part of the front wall. These affect mostly the center fill of the stage, as shown in Figure 6. Rotating these Tube Traps with their seam toward the front wall, so they are more reflective into the room, will solidify the musicians located center stage (including center stage rear), instead of leaving them sounding somewhat ghostlike. It will also allow you to move the speakers farther apart, to obtain better stage width without creating a hole in the middle. Beware though of making the Tube Traps at the rear of the speakers too reflective, for that will cause midrange honk or glare, with loss of stage depth.

The Tube Traps in the front corners can be rotated to affect the perceived depth of the far corners of the stage. Again, be careful not to allow so much reflection that you pick up midrange honk or glare from the room corners.

Throughout this exercise, the goal is to hear less of your listening room walls, while hearing more of the recording stage, hall walls, and hall space.

Finally, the pair of columns in between the speakers can be fine tuned to affect the 3D projection of front center stage soloists. This pair of columns is very sensitive to the slightest change in rotational alignment and in location, relative to the speakers and relative to each other. When optimized just right, you can achieve a spooky magical quality in which center soloists are not only tactilely solid, but also are holographically projected as 3D entities in this space between the speakers. You can also try extending this line of columns toward the listener, with three or more columns.

Well, there you have it. I've helped you get the best sound out of your room as much as I can — short of personally setting up and fine tuning your listening room with Tube Traps. Happy listening!